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# Geotechnical Solution For Engineering Properties Improvement In Expansive Soil Using Fly Ash

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**ABSTRACT**
Nearly 51.8 million hectares of land area in India are covered with Expansive soil (mainly Black Cotton soil). The property of these expansive soils, in general, is that they are very hard when in dry state, but they lose all of their strength when in wet state. In light of this property of expansive soils, these soils pose problems worldwide that serve as challenge to overcome for the Geotechnical engineers. One of the most important aspects for construction purposes is soil stabilization, which is used widely in foundation and road pavement constructions; this is because such a stabilization regime improves engineering properties of the soil, such as volume stability, strength and durability. With various proportions of this additive i.e. 10%, 20%, 30%, 40% & 50%, expansive soils is stabilized. Owing to the factthat fly ash possess no plastic property, plasticity index (P.I.) of clay-fly ash mixes show a decrease in value with increasing fly ash content. In conclusion, addition of fly ash results in decrease in plasticity of the expansive soil, and increase in workability by changing its grain size and colloidal reaction. Tested under both soaked and un-soaked conditions, the CBR values of clay with fly ash mixes were observed. Analysis of the formerly found result exposes the potential of fly ash as an additive that could be used for improving the engineering properties of expansive soils.
**Keywords:** Expansive soils, stabilization, fly ash, UCC, CBR,

## 1. INTRODUCTION

The soil is a complex and essential construction material. In the eve of soil improvement conferences have given a big boost to the soil engineers to perform reams of research in order to improve the soil characteristics and develop stable skyscrapers Deformation due to the expansive soil is significantly greater than elastic deformations. These cannot be forecasted by the classical elastic and plastic theories. Movement is usually in an uneven pattern developed by expansive soil with magnitude to cause extensive damage to the structures resting on them. The ill effects can be reduced, once recognized the type of soil using requisite tests in the preliminary stage of construction. The expansive soil shows low bearing capacity, low shear strength and high compressibility, low permeability and thus it is found to be unsuitable as a construction material for various purposes.

Fly ash is a fairly divided residue which results from the combustion of ground or powdered bituminous coal or sub- bituminous coal like lignite and transported by the flue gases of boiler fired by pulverized coal or lignite. Chemical properties of fly ash include chemical composition, pH values, lime reactivity, and cation Exchange Capacity. The chemical composition of fly-ash differs with sources of production of fly-ash. The fly ash constitutes silicon dioxide, aluminum oxide, ferric oxide along with pozzolanic reaction forming Hydrated Lime (63.2-70 ppm). It is a colorless compound having cementitious properties. When mixed with soil act as a binding material

between the soil particles and retard swelling and shrinkage of the soil. As per Cokca (2011) mixing fly-ash with the soil (25% by wt. of dry soil) bring down the swelling potential of the soil by 30%. Pandean (2002) studied the effect of two types of fly ashes Raichur fly ash (class F) and Neyveli fly ash (class C) on the CBR characteristics of the black cotton soil. The fly ash content was increased from 0 to 100%. The addition of fly ash to black cotton soil increased the CBR of the mix up to the first optimum level. Further addition of fly ash beyond the optimum level caused a decrease up to 60% and then up to the second level there was an increase.

In this study locally available fly-ash i.e. Unchanhar NTPC plant fly ash is used. The result shows an increase of strength of specimen mixed with fly ash due to the changes that occur in the texture of the soil. Also the plasticity index (P.I.) of clay-fly ash mixes shows a decrease in value with increasing fly ash content.

## 1. 1.1 Laboratory Identification

Laboratory identification tests for expansive soils includes grain size analysis, Atterberg's limit, swelling pressure, free swell index, light compaction, permeability test, unconfined compression test, one dimensional consolidation etc. are performed in the laboratory as per IS specifications

## 2. 2. MATERIAL USED

2.1 Expansive soil: Expansive soil sample is taken from Lambhua Sultanpur (U.P.). The soil was air dried and pulverized manually. Natural soil has the swelling and shrinkage properties in the present of moisture. This expansive soil is yellow and light grey in color. Basic properties of the natural untreated expansive soil used in experiment work are presented in table1.

**Table.1 Properties of Expansive soil**

| S.No | Properties | Values |
|---|---|---|
| 1 | Clay content | 87.9 % |
| 2 | Silt content | 3.9 |
| 3 | Fine sand | 4.8 |
| 4 | Medium sand | 3.4 |
| 5 | Classification of soil | CH |
| 6 | Liquid limit | 69.2 % |
| 7 | Plastic limit | 25.3 % |
| 8 | Plasticity Index | 43.9 % |
| 9 | Shrinkage limit | 10.1 |
| 10 | Specific gravity | 2.55 |
| 11 | Free swell index | 67% |
| 12 | MDD | 1.78 g/cc |
| 13 | OMC | 12.4 % |
| 14 | UCS | 1.52 kg/cm² |
| 15 | Swelling Pressure | 1.70 kg/cm$^2$ |

**2.2 Fly ash: The fly ash sample collected from Unchanhar NTPC plant. The chemical and engineering properties of fly ash are presented in table 2.**

## 3. Table.2: Engineering properties of Fly ash

| S.No | Properties | Values |
|---|---|---|
| 1 | Loss of Ignition | 1.75 |
| 2 | Silica ($SiO_2$) | 56.12 |
| 3 | Mixed Oxide ($R_2O_2$) | 28.02 |
| 4 | Total Chloride | 0.035 |
| 5 | Calcium Oxide (CaO) | 10.54 |
| 6 | Magnesium Oxide | 1.19 |
| 7 | Na (as $Na_2$) | 0.23 |
| 8 | K (as $Na_2$) | 0.46 |
| 9 | Classification of Fly ash | C |

| | | |
|---|---|---|
| 10 | Silt content | 53.58% |
| 11 | Fine sand | 43.16% |
| 12 | Medium sand | 3.26 |
| 13 | Liquid limit | 64.8 % |
| 14 | Specific gravity | 2.06 |
| 15 | MDD | 1.12 g/cc |
| 16 | OMC | 29 % |

## 3. METHODOLOGY

To evaluate the effect of fly ash as a stabilizing agent in expansive soil, series of tests, where the content of fly ash in the expansive soil was varied in values of 10% to 50% (multiple of 10), by weight of the total quantity taken. The Indian Standard codes were followed during the conduction of the following experiments:

- Specific Gravity test
- Liquid & Plastic limit test – IS 2720 (Part 5) – 1985
- Indian Light weight compaction test (for OMC-MDD) – IS 2720 (Part 8) – 1983
- Unconfined compressive strength (UCS) test – IS : 2720 (Part 10) - 1991
- California bearing ratio (CBR) test – IS : 2720 (Part 16) - 1987
- Free swell index test – IS 2720 (Part 40) - 1977

## 4. 4. RESULTS AND DISCUSSIONS

### 5. 4.1 RESULTS:

**6. Table1. Expansive Soil in add fly ash mixture**

| S.No. | Sample | | Atterberg limit (%) | | | F.S.I. | UCS | CBR Value |
|---|---|---|---|---|---|---|---|---|
| | Soil (%) | Flyash (%) | LL | PL | SL | | KN/m$^2$ | |
| 1 | 100 | 0 | 65 | 37.08 | 17.35 | 95 | 18 | 1.65 |
| 2 | 90 | 10 | 57 | 38.09 | 17.05 | 74 | 18.4 | 1.66 |
| 3 | 80 | 20 | 53 | 36.2 | 16.6 | 63 | 19 | 1.7 |
| 4 | 70 | 30 | 51 | 33.42 | 16 | 60 | 19.5 | 1.98 |
| 5 | 60 | 40 | 47 | 30.16 | 15.6 | 50 | 19.2 | 1.95 |
| 6 | 50 | 50 | np | np | 14 | 49 | 18.85 | 1.82 |

As the fly ash contains slity size particles, the consistency limits (i.e. L.L. and P.L.) of the soil specimen when mixed with fly-ash was found to be decreasing with the increase in the fly-ash content (0%-50%).

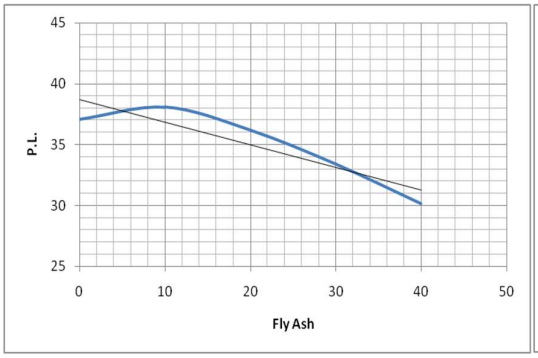


*Fig.-1 Fly Ash (%) vs. P.L*

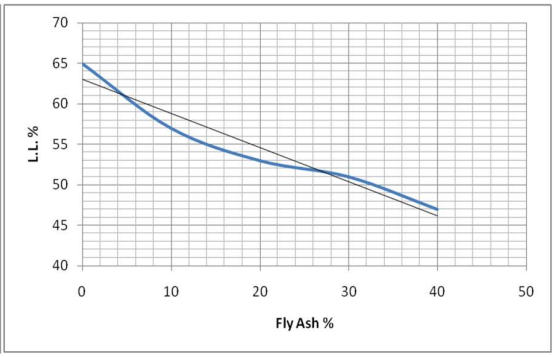


*Fig.2 Fly Ash (%) vs. L.L*

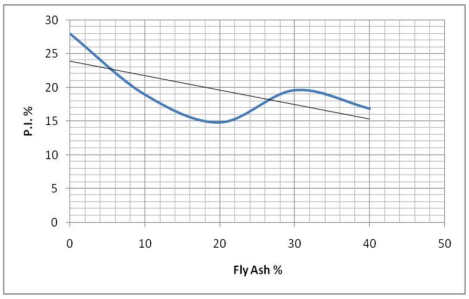


*Fig.-3 Fly Ash (%) vs. P.I*

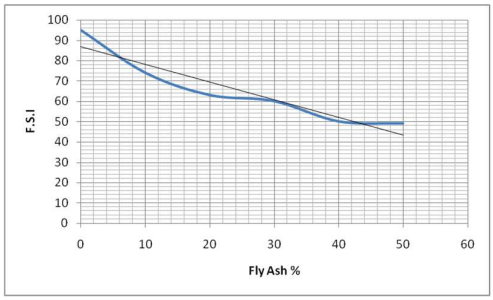


*Fig.-4 Fly Ash (%) vs. F.S.I*

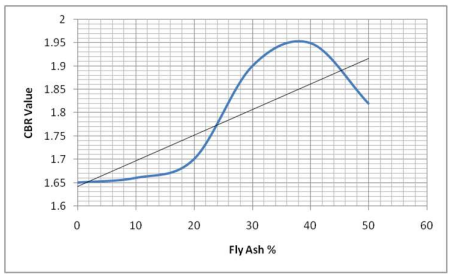


*Fig.-5 Fly Ash (%) vs. CBR Value*

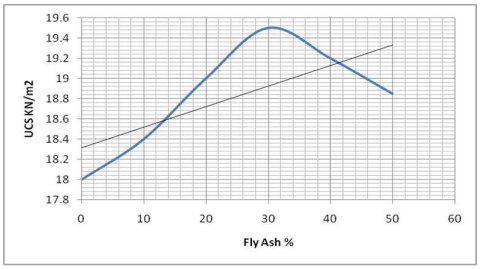


*Fig.-6 Fly Ash (%) vs. UCS MK/m2*

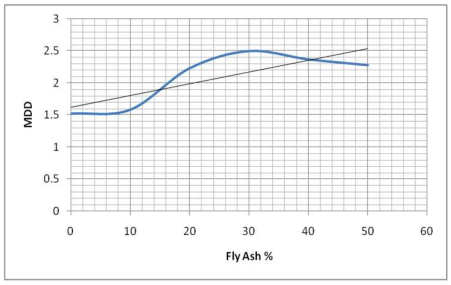


*Fig.-7 Fly Ash (%) vs. MDD*

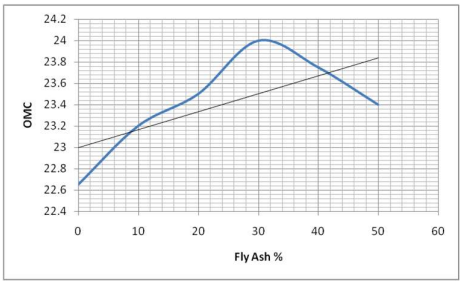


*Fig.-8 Fly Ash (%) vs. OMC*

**4.2 DISCUSSION**

Owing to the fact that fly ash possess no plastic property, plasticity index (P.I.) of clay-fly ash mixes showed a decrease in value with increasing fly ash content. The swelling property i.e. FSI of the soil specimen showed improvement with the increase in the fly-ash content in the soil specimen as shown in table 1 and fig 4. This was due to increase in silica size particle in the soil mass leading to decrease in the thickness of diffused layer around the clayey soil particle and overall decrease in the percentage of clay mineral in the soil specimen.

The maximum dry density was found to be maximum for 30% fly-ash content in the specimen while optimum moisture content increased with the increase in the fly-ash content which might be due to decrease in the clay mineral with fly-ash content which lead to more denser configuration, resulting in higher density. With further increase in the fly ash content, the presence of free water increases in specimen leading to decrease in the MDD. (Fig 7 and OMC Fig. 8) There was also increase in the unconfined compressive strength of the soil specimen with increase in fly-ash content from 0% to 30% but the CBR value showed upward trend only up to 40% fly-ash content and reduced when fly-ash content was further increased to 50% (fig 6 and fig 5). Over all with addition of fly-ash, soil specimen showed improvement up to 30% fly-ash content.

**5. CONCLUSION**

The objective of present study was to improve the swelling and shrinkage characteristics the expensive soil by using cheap and locally available waste material i.e. fly-ash. With various proportions of this additive i.e. 10%, 20%, 30%, 40% & 50%, expansive soils is stabilized.

**i.** The result shows that with addition of fly ash (upto 30% of wt) to the clayey soil decrease in plasticity index of the expansive soil.

ii. The result shows that the addition of fly ash (upto 30% of wt) to the clayey soil reduces the swelling potential and then increases.
iii. The result shows that the addition of fly ash (upto 30% of wt) to the clayey soil with increase in CBR value after then decreases.
iv. The result shows that the addition of fly ash (upto 30% of wt) to the clayey soil increases its shear strength property and after that decreases.
v. The result shows that the addition of fly ash (upto 30% of wt) to the clayey soil increases Maximum Dry Density and then decreases.
vi. The result shows that the addition of fly ash (upto 30% of wt) to the clayey soil reduces the optimum moisture content and then increases.

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